PLUTONIUM CONTAMINATION AT THULE

Summary of Notes for Talk

Given at DOE Meeting on Proposed

EPA Guidelines for Transuranium

Elements in the Environment

January 17, 1984

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On January 21, 1968, a B-52 carrying 4 nuclear weapons crashed and burned on the ice near Thule, Greenland. The 7 crew members bailed out before the crash and 6 survived. At the time of the crash, the plane was carrying about 225,000 pounds of JP-4 jet fuel. The resultant fire produced a blackened area on the ice of about 500 feet wide by 2100 feet long. The ice was cracked for about 100 yards in all directions from the point of the impact.

At the time of the crash, the temperature was -24°F and a 7 knot wind reduced this to an equivalent -53°F reading. It would be about 3 weeks yet until the sun made its first appearance after the long Artic night. During the next few weeks, several storms swept the area. The combination of darkness, storms, severe cold, and the remote location would make recovery operations extremely difficult.

Within a few days, members of the U.S. Air Force, scientific experts from LASL and Livermore, and Danish scientists were assembled at Thule to assess the accident situation. It quickly became clear that there was plutonium contamination around the crash site, but there was no evidenace of any nuclear yield. Also, it was determined that the ice at the crash site was 2 to 4 feet thick and sufficient to support vehicles and structures as long as adequate spacing was maintained.

One of the first priorities was to establish the extent of the contamination around the crash site and determine a zero line outside of which no contamination was detectible. The most valuable instrument for mapping the contamination level was the FIDLER detector developed at Livermore. This instrument is designed to detect the low energy x-rays (14 keV to 20 keV) from plutonium and the 60 keV photon from Am-241. Because of the snow cover, the 60 keV photons from ^{241}Am produced better sensitivity and were used for contamination contour mapping and hot-spot identification.

Thorough surveys of the contaminated area produced the isocontamination contour map shown in Figure 1. It was estimated that there were about 3150 g ($\pm$ 20%) of plutonium on the surface of the ice. About 99% of the contamination was confined to the blackened crust where the fuel had burned. The edge of the blackened crust was closely coincident with the 0.9 mg/m^2 isocontour line. This level is about 400 times greater than the proposed EPA "screening level" of 0.2 uCi/m^2 for transuranic contamination in soil.

Snow samples were taken by Danish scientists at numerous locations (primarily to the south and west) away from the immediate crash site. The maximum contamination level observed was 0.4 uCi/m^2. The geometric mean of all the samples was about 0.004 uCi/m^2.

One of the major constraints in the clean up operation was that whatever actions that were going to be taken on the ice had to be finished by the later part of April when the ice would become unsafe to work on. Whatever plutonium

contamination remained on or in the ice at that time would disappear into the bay.

It was decided to remove all of the snow inside of the blackened zone which included an area of about 60,000 m^2. With an average snow depth of 10 cm, this would produce a volume of 6000 m^3. Assuming that the volume ratio of packed snow to water would be about 2.5, this would produce about 6×10^5 gallons of water. After all of the aircraft debris had been removed from the ice, the snow in the blackened area was scraped into rows, picked up and transferred into sixty-seven 25,000 gallon tanks.

In the area of the aircraft impact, the ice had been broken, melted, and refrozen. To assess the level of contamination in the ice, 85 core samples were taken in the fractured area. There was plutonium contamination associated with black bands distributed in the ice which were produced by burned fuel. It was estimated that about 350 g of plutonium were contained in the roughly 2000 tons of ice. Studies showed that when samples of the ice were melted, essentially all of the plutonium contamination sank to the bottom. Another 48 core samples were taken outside the fractured area. They disclosed no contamination in or under the ice.

A decision was made to let the contaminated ice melt in place for three reasons. First, even if the plutonium were to stay suspended in water, it would rapidly be reduced to non-hazardous levels by dispersion. Second, it was likely that the plutonium would settle into the sediment layer on the

bottom of the bay and become effectively isolated from the inhabitants in the area. And third, the clean-up operations which had already taken place were not completed until the end of March, which left only a few weeks before the ice would become unsafe to work on.

Many environmental surveys have been conducted by Danish scientists in the years since the accident. These surveys have focused on determining the levels and distribution of plutonium contamination in the marine environment and investigating the possible impact that might be transmitted through the food chain to the Greenlanders (see Figure 2). The surveys have produced the following major conclusions:

1. The inventory of plutonium in the sediment on the bottom of the bay is about 30 Ci. The maximum concentration under the crash site is about 50 pCi/g (see Figure 3). The vertical displacement of the plutonium is about 7-8 mm/y which indicates that it will become increasingly unavailable to the biota in the sediments.

2. Plutonium has been found in increased quantities (up to 6 pCi/g) in the organisms (mussels, starfish, and shrimp) that live in the sediment, but the concentrations are decreasing with time.

3. Certain seaplants have been found to concentrate plutonium by a factor of about 13,000.

4. In 1979, seawater did not contain measurable amounts of plutonium from the accident, except in particles just above the seabed at the point of impact.

5. In the most recent environmental survey completed in 1979, plutonium from the accident was not detected in any of the higher animals (birds, fish, mammals) with any certainty. The contamination has been confined to the sediment and those organisms that live in or on the sediment.

The only direct link between the Greenlanders and the portion of the foodchain with detectable plutonium contamination is through the mussels (bivalves). In 1974, the average concentration of plutonium in the soft parts of the mussels found within a radius of 20 km of the crash site was about 20 pCi/kg. If we asume that a Greenlander eats 100 grams of mussels a day from this region for 70 years, the estimated annual dose rate to the bone at the end of 70 years would be .075 mrad (from EPA 520/-77-016, Table A3-6). Even with this extremely conservative scenario, the projected maximum annual dose rate is less than 3% of the proposed EPA limit.

I was unable to find any cost estimates for the clean up operation at Thule. It involved the resources and people of many organizations and would be difficult to reconstruct. However, since the clean up operations apparently were sufficient to meet the requirements for limiting exposures to individuals as currently proposed by the EPA, it is my opinion that the clean up costs wouldn't be appreciably different today than they were then, save the adjustment for inflation.

REFERENCES

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2. Aarkrog, A, "Environmental Behavior of Plutonium Accidentally Released at Thule, Greenland", Health Physics, Volume 32, No. 4, April 1977.

3. Aarkrog, A, et al., "Radioecological Investigations of an Environmental Contamination with Transuranic Elements", 1980 Progress Report, Radiation Protection, Commission of European Communities.

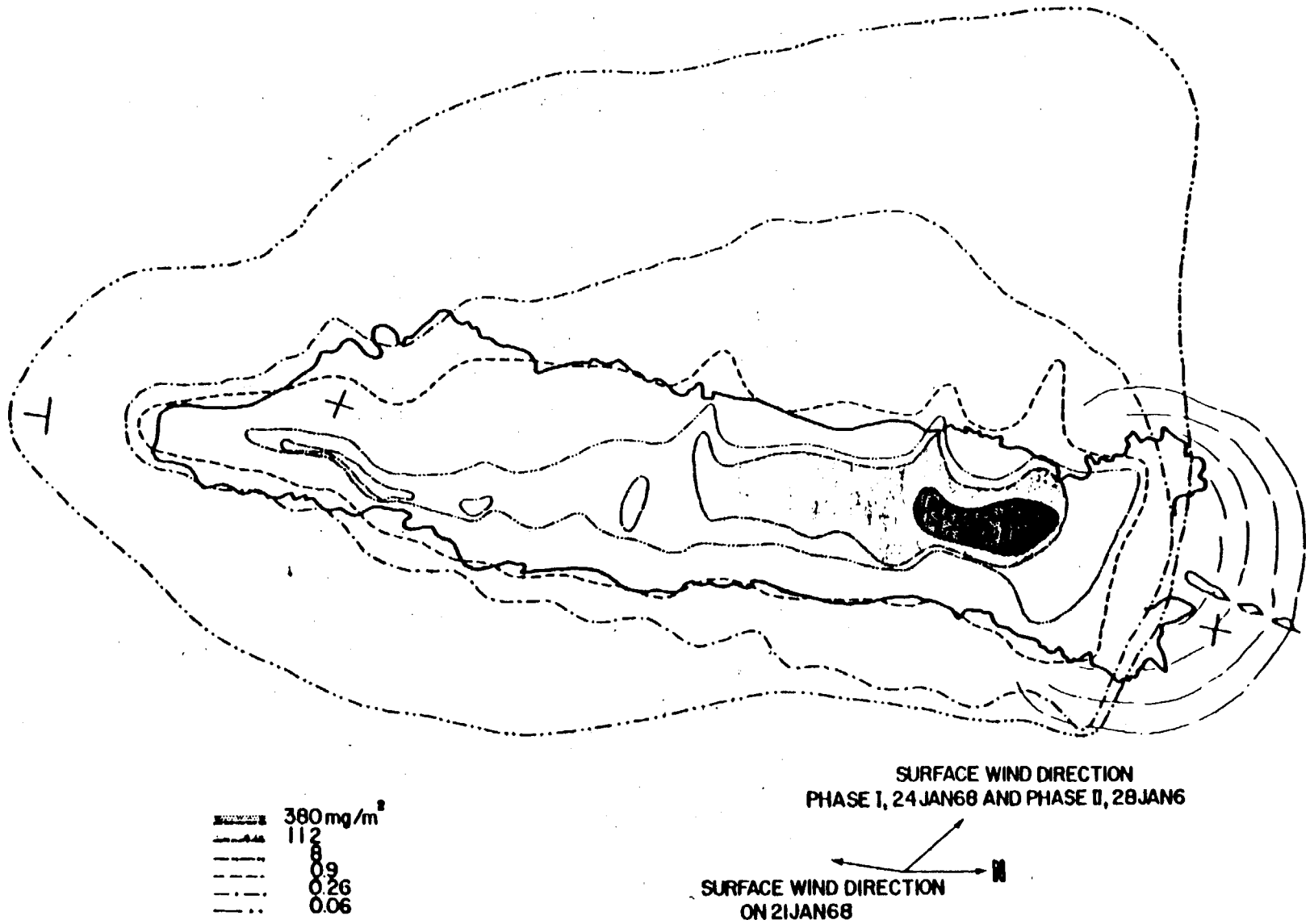

Figure 1 Plutonium contamination levels observed.

Taken from reference 1

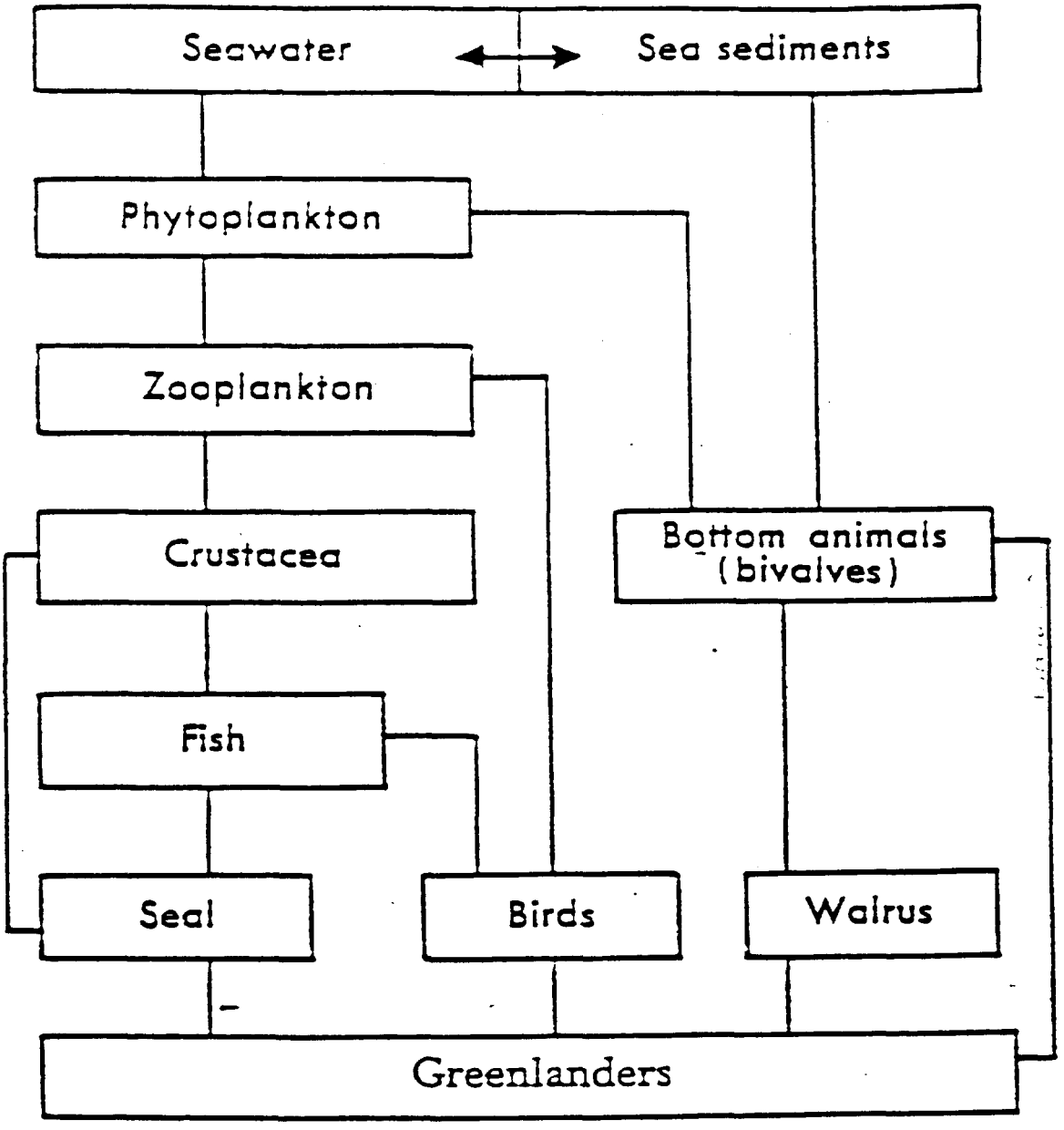

Figure 2. Food chains in an arctic, marine environment.

Taken from reference 1

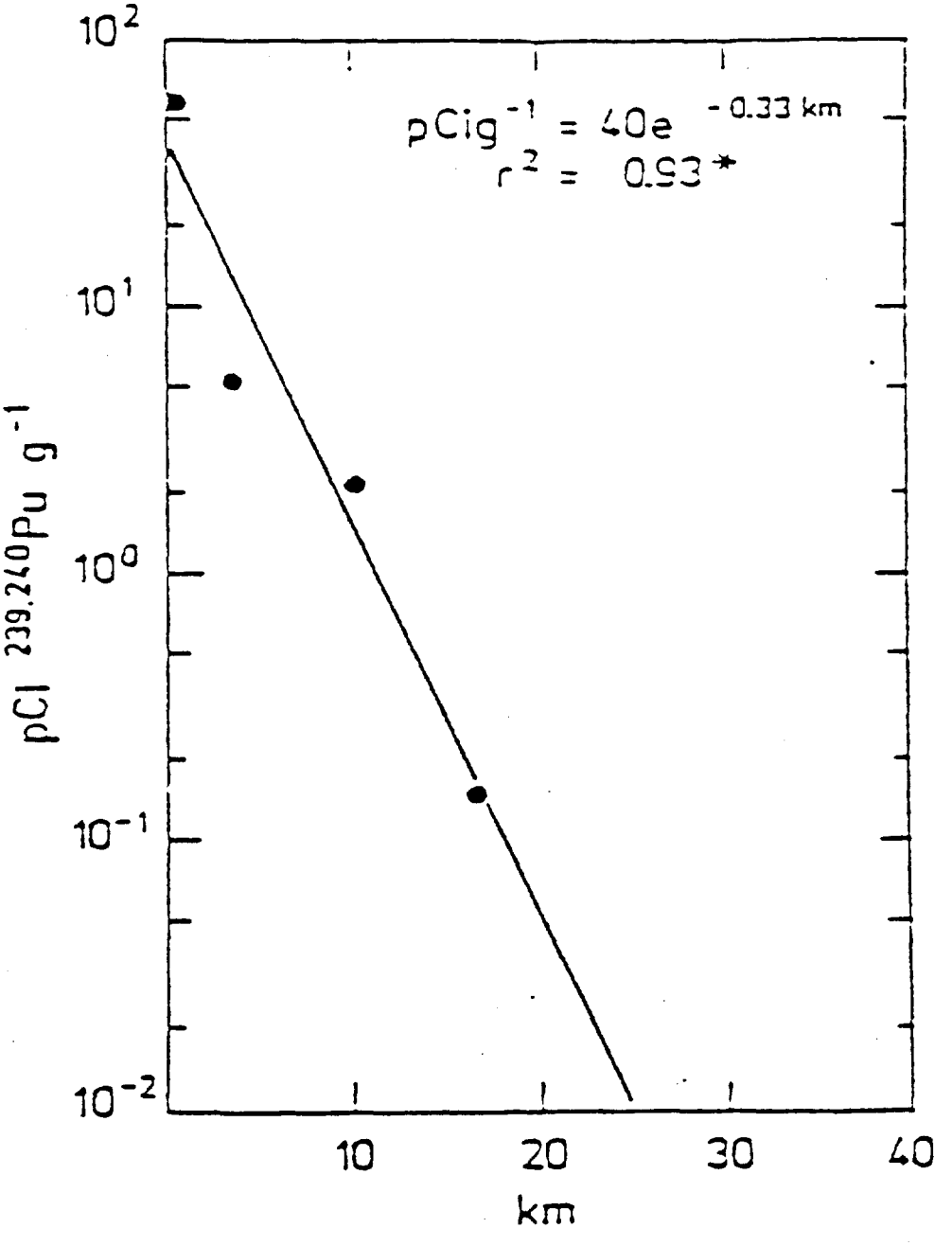

FIG. 3. The ^{239,240}Pu concentration in the sediment surface (0 cm depth) related to the distance (in km) from the point of impact.

Taken from reference 3